US007517056B2

(12) United States Patent
Fellner et al.

(10) Patent No.: US 7,517,056 B2
(45) Date of Patent: Apr. 14, 2009

(54) **FLUID EJECTION DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 343 days.

(21) Appl. No.: **11/352,678**

(22) Filed: **Feb. 13, 2006**

(65) **Prior Publication Data**

US 2006/0268071 A1 Nov. 30, 2006

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/140,802, filed on May 31, 2005, now Pat. No. 7,431,434.

(51) **Int. Cl.**
B41J 2/05 (2006.01)

(52) **U.S. Cl.** **347/56**; 347/65

(58) **Field of Classification Search** 347/20, 347/56, 61–65, 67, 92–94
See application file for complete search history.

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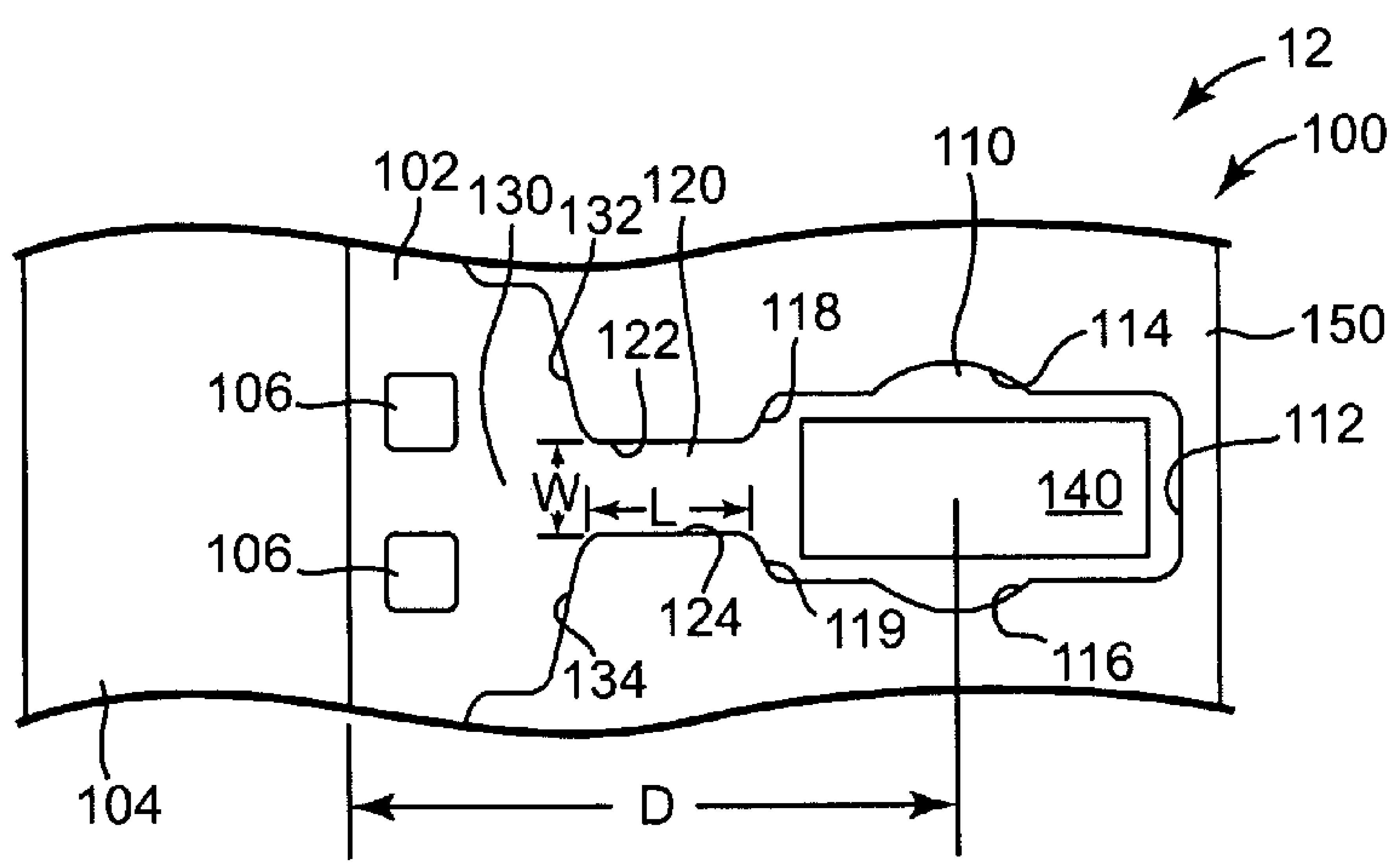
(57) **ABSTRACT**

A fluid ejection device includes a fluid chamber, a fluid restriction communicated with the fluid chamber, and a fluid channel communicated with the fluid restriction. The fluid restriction has a fluid restriction parameter defined as (2*W+2*H)*L/(H*W), wherein W is a width of the fluid restriction, H is a height of the fluid restriction, and L is a length of the fluid restriction. As such, the fluid restriction parameter is in a range of 1.5 to 5.75.

20 Claims, 5 Drawing Sheets



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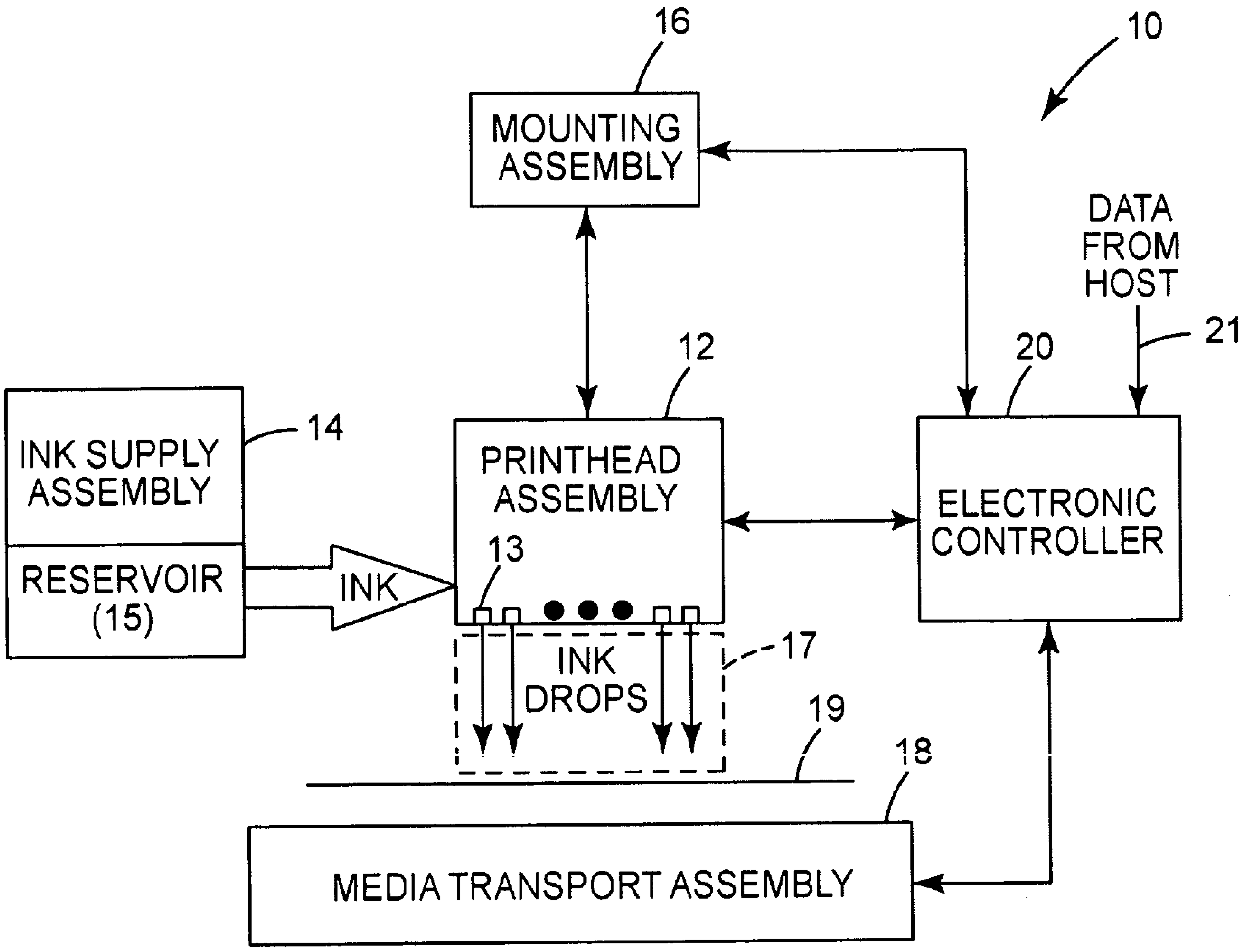
16
10
MOUNTING ASSEMBLY
DATA FROM HOST
12
20
21
14
INK SUPPLY ASSEMBLY
PRINTHEAD ASSEMBLY
ELECTRONIC CONTROLLER
RESERVOIR (15)
INK
13
INK DROPS
17
19
18
MEDIA TRANSPORT ASSEMBLY

Fig. 1

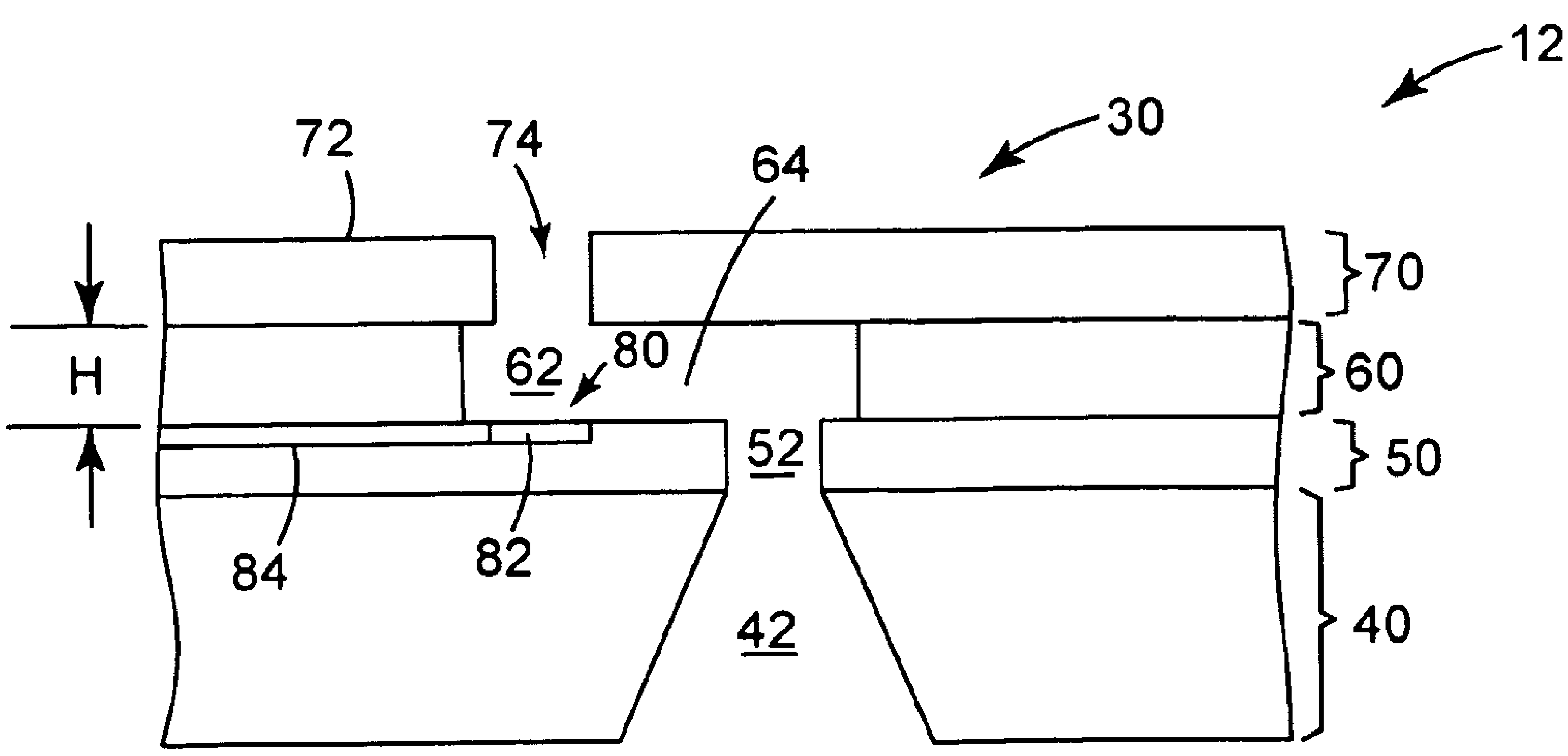
12
30
72
74
64
70
H
62
80
60
52
50
84
82
42
40

Fig. 2

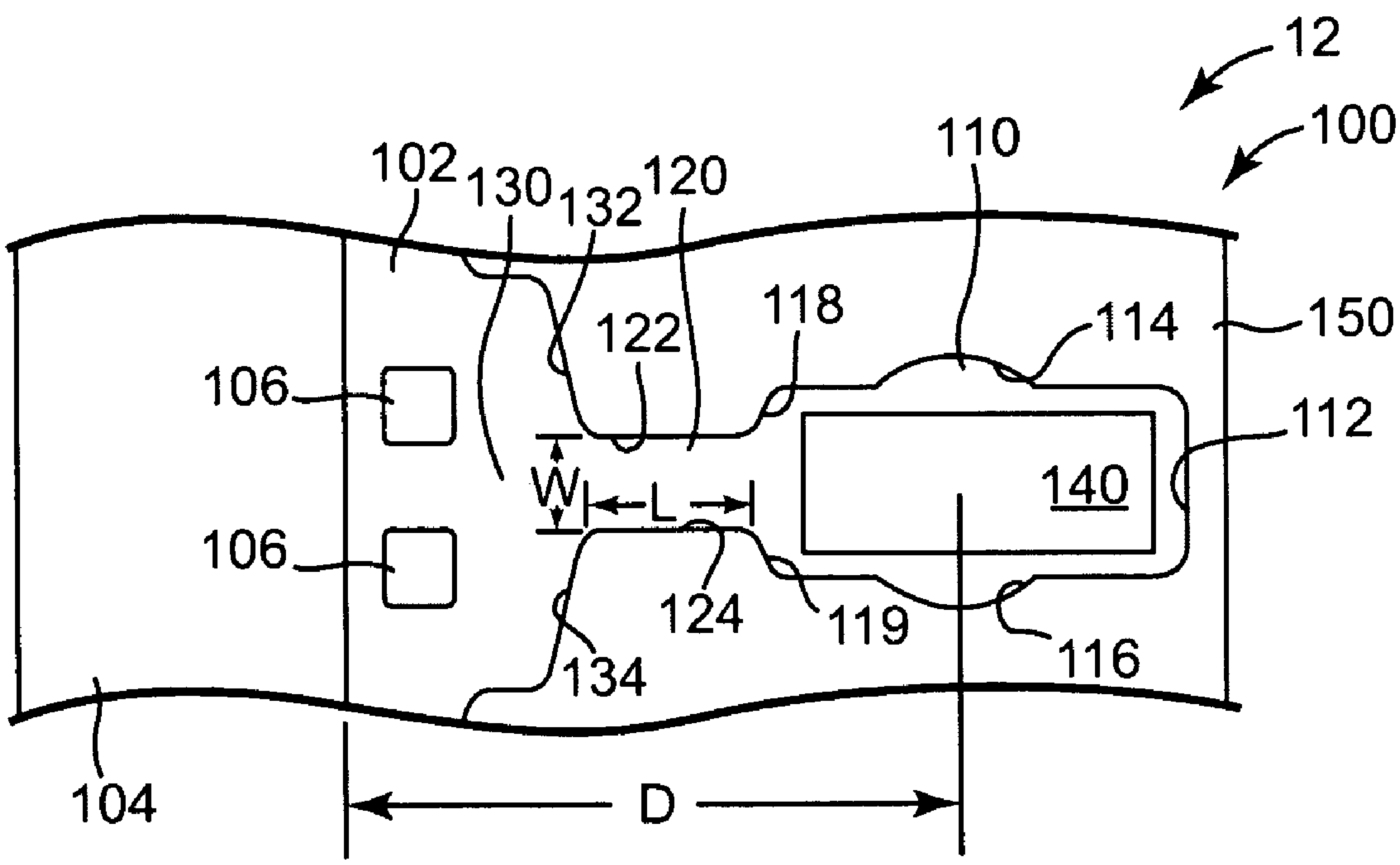
12
100
102
130
132
120
110
118
114
150
122
106
112
W
L
140
106
124
119
116
134
104
D

Fig. 3

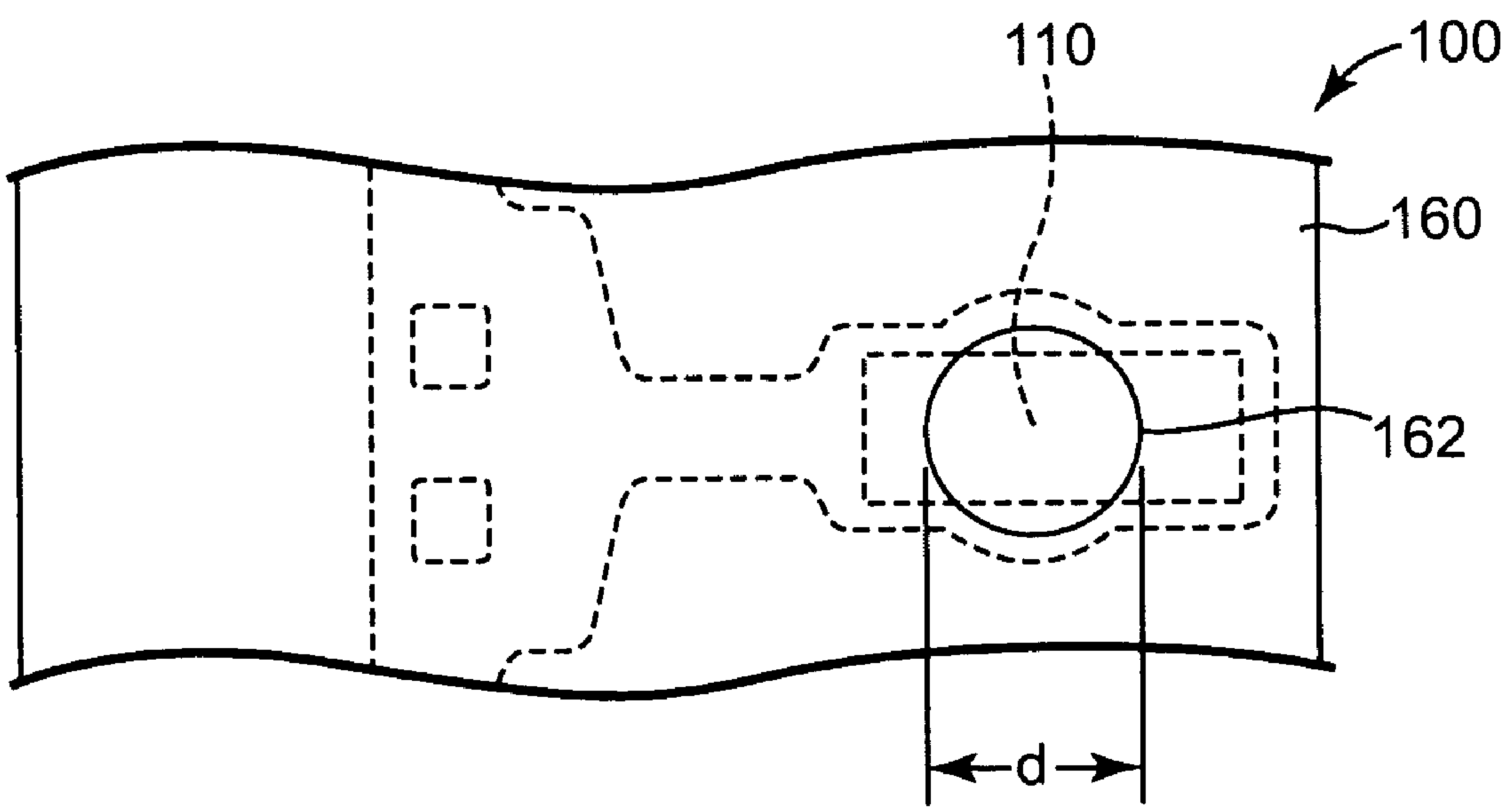
110
100
160
162
d

Fig. 4

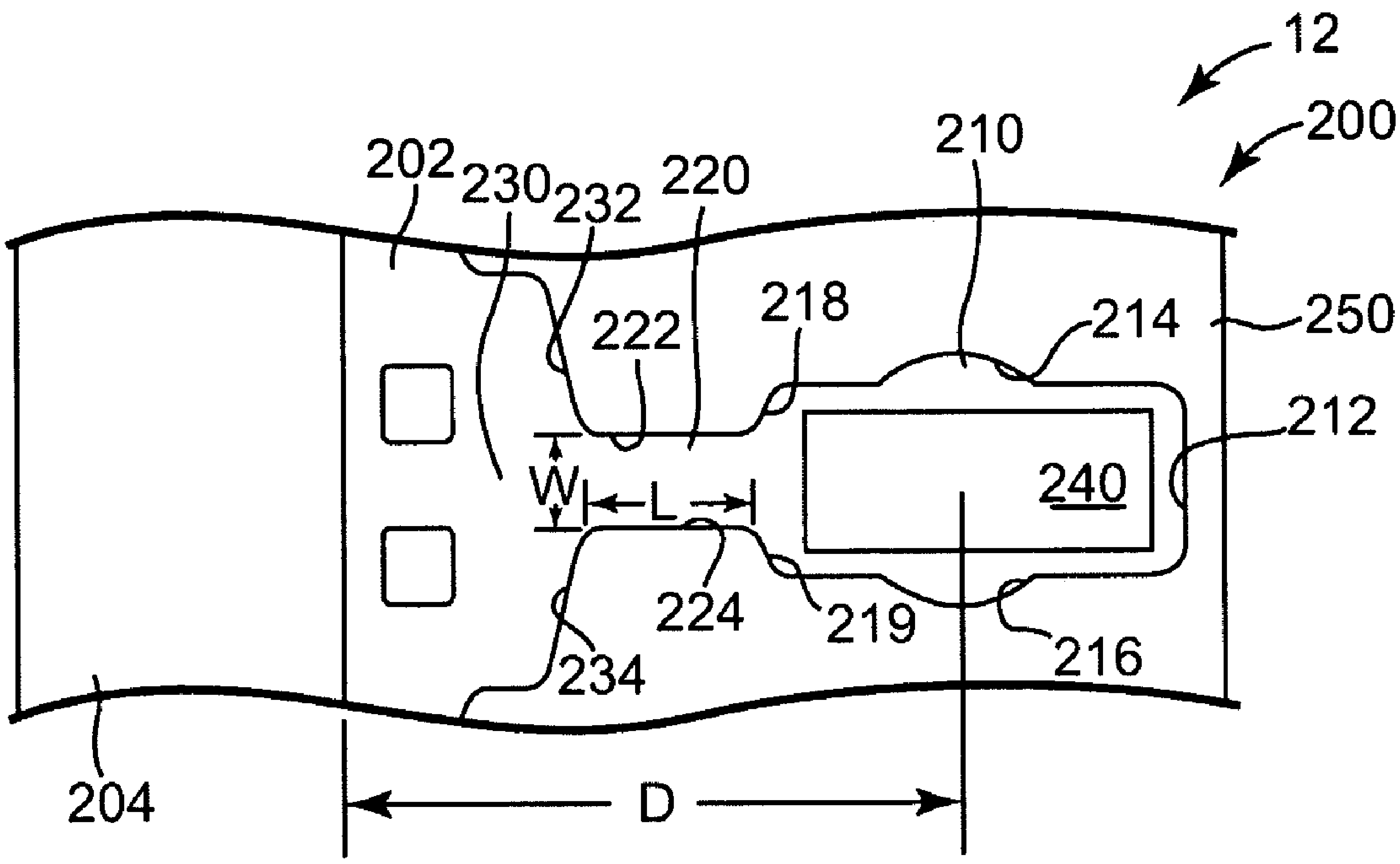
12
200
202
230
232
220
210
218
222
214
250
212
240
W
L
224
219
234
216
204
D

Fig. 5

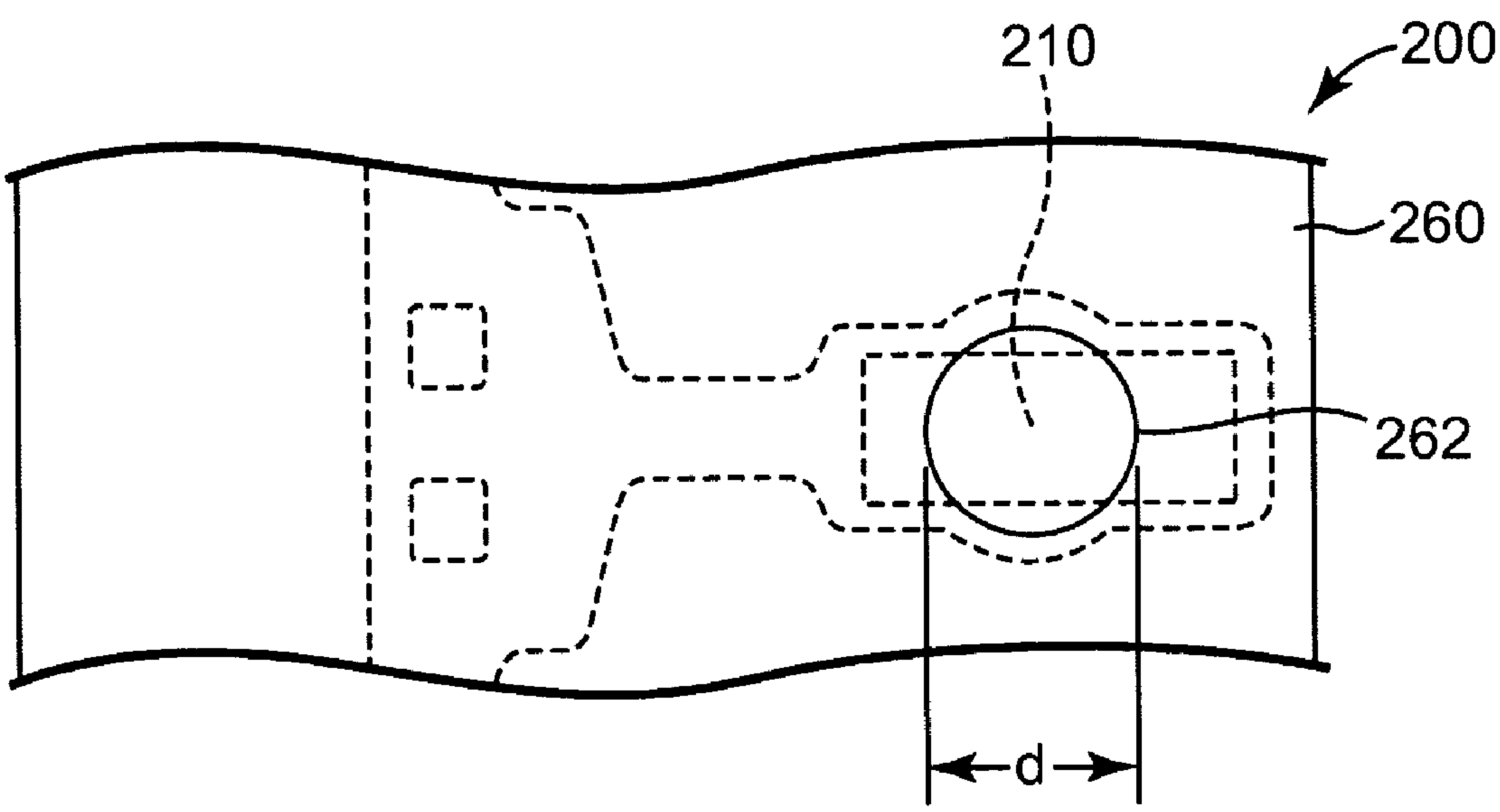
210
200
260
262
d

Fig. 6

ORIFICE LAYER THICKNESS	20 +/- 1 um				
INK PROPERTIES	**INK #1**	**INK #2**	**INK #3**	**INK #4**	**RANGE**
INK VISCOSITY (cP)	2.5	1.8-3.2	2.6-3.8	2.3	1.5-4.0
INK SURFACE TENSION (dynes/cm)	33	25.3-27	22.1-24	25.4	21-35
SYSTEM PERFORMANCE	**INK #1**	**INK #2**	**INK #3**	**INK #4**	**RANGE**
DROP WEIGHT (ng)	9.6	7.9	6.1	6.5	5.5-10.5
DROP VELOCITY (m/s)	10.8	11.4	12.6	11.3	10 -14
FREQUENCY RANGE (kHz)	0-48	0-36	0-48	0-48	0-48
DESIGN PARAMETERS	**INK #1**	**INK #2**	**INK #3**	**INK #4**	**RANGE**
RESISTOR AREA (um^2)	575	462	360	360	325-625
RESISTOR SIZE (um)	24	21.5	19	19	18-25
ORIFICE DIAMETER, d (um)	17.2	17.2	15	15	14-18.5
SHELF LENGTH, D (um)	47.2-56.8	47.2-56.9	47.2-56.10	47.2-56.11	45-58
FLUID RESTRICTION PARAMETER =(2*W+2*H)*L/(H*W)	1.71	1.71	3.06	5.51	1.5 -5.75

Fig. 7

ORIFICE LAYER THICKNESS	14 +/- 1 um				
INK PROPERTIES	**INK #1**	**INK #2**	**INK #3**	**INK #4**	**RANGE**
INK VISCOSITY (cP)	2.8	2.9-3.2	2.7	1.9-2.4	1.5-3.5
INK SURFACE TENSION (dynes/cm)	24	23.9-25.3	21.7	21.4-29.1	21-30
SYSTEM PERFORMANCE	**INK #1**	**INK #2**	**INK #3**	**INK #4**	**RANGE**
DROP WEIGHT (ng)	6.5	6.2	5.5	4.2	3.5-7.5
DROP VELOCITY (m/s)	11.5	12.2	10	13.6	8-15.5
FREQUENCY RANGE (kHz)	0-48	0-36	0-36	0-48	0-48
DESIGN PARAMETERS	**INK #1**	**INK #2**	**INK #3**	**INK #4**	**RANGE**
RESISTOR AREA (um^2)	420	393	350	260	200-475
RESISTOR SIZE (um)	20.5	19.8	18.7	16.1	14-22
ORIFICE DIAMETER, d (um)	16.4	16	16	13	12-17.5
SHELF LENGTH, D (um)	47.2-56.8	47.2-56.8	47.2-56.8	47.2-56.8	45-58
FLUID RESTRICTION PARAMETER =(2*W+2*H)*L/(H*W)	1.66	1.66	4.29	3.93	1.5 -4.5

Fig. 8

FLUID EJECTION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation-In-Part of U.S. patent application Ser. No. 11/140,802, filed on May 31, 2005, now U.S. Pat. No. 7,431,434 assigned to the Assignee of the present invention, and incorporated herein by reference.

BACKGROUND

An inkjet printing system, as one embodiment of a fluid ejection system, may include a printhead, an ink supply which supplies liquid ink to the printhead, and an electronic controller which controls the printhead. The printhead, as one embodiment of a fluid ejection device, ejects drops of ink through a plurality of nozzles or orifices and toward a print medium, such as a sheet of paper, so as to print onto the print medium. Typically, the orifices are arranged in one or more columns or arrays such that properly sequenced ejection of ink from the orifices causes characters or other images to be printed upon the print medium as the printhead and the print medium are moved relative to each other.

In one arrangement, the printhead may accommodate different color inks, such as black ink and/or one or more colored inks. The different color inks, however, may have different properties and, therefore, different performance characteristics. Accordingly, to optimize performance of the printhead, it is desirable to select or tune parameters of the printhead to accommodate one or more different inks.

SUMMARY

One aspect of the present invention provides a fluid ejection device. The fluid ejection device includes a fluid chamber, a fluid restriction communicated with the fluid chamber, and a fluid channel communicated with the fluid restriction. The fluid restriction has a fluid restriction parameter defined as (2*W+2*H)*L/(H*W), wherein W is a width of the fluid restriction, H is a height of the fluid restriction, and L is a length of the fluid restriction. As such, the fluid restriction parameter is in a range of 1.5 to 5.75.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating one embodiment of an inkjet printing system according to the present invention.

FIG. **2** is a schematic cross-sectional view illustrating one embodiment of a portion of a fluid ejection device according to the present invention.

FIG. **3** is a plan view illustrating one embodiment of a portion of a fluid ejection device according to the present invention.

FIG. **4** is a plan view illustrating one embodiment of including an orifice layer with the fluid ejection device of FIG. **3**.

FIG. **5** is a plan view illustrating another embodiment of a portion of a fluid ejection device according to the present invention.

FIG. **6** is a plan view illustrating one embodiment of including an orifice layer with the fluid ejection device of FIG. **5**.

FIG. **7** is a table outlining one embodiment of exemplary parameters and exemplary ranges of parameters of a fluid ejection device according to the present invention.

FIG. **8** is a table outlining another embodiment of exemplary parameters and exemplary ranges of parameters of a fluid ejection device according to the present invention.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as "top," "bottom," "front," "back," "leading," "trailing," etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

FIG. **1** illustrates one embodiment of an inkjet printing system **10** according to the present invention. Inkjet printing system **10** constitutes one embodiment of a fluid ejection system which includes a fluid ejection device, such as a printhead assembly **12**, and a fluid supply, such as an ink supply assembly **14**. In the illustrated embodiment, inkjet printing system **10** also includes a mounting assembly **16**, a media transport assembly **18**, and an electronic controller **20**.

Printhead assembly **12**, as one embodiment of a fluid ejection device, is formed according to an embodiment of the present invention and ejects drops of ink, including one or more colored inks, through a plurality of orifices or nozzles **13**. While the following description refers to the ejection of ink from printhead assembly **12**, it is understood that other liquids, fluids, or flowable materials may be ejected from printhead assembly **12**.

In one embodiment, the drops are directed toward a medium, such as print media **19**, so as to print onto print media **19**. Typically, nozzles **13** are arranged in one or more columns or arrays such that properly sequenced ejection of ink from nozzles **13** causes, in one embodiment, characters, symbols, and/or other graphics or images to be printed upon print media **19** as printhead assembly **12** and print media **19** are moved relative to each other.

Print media **19** includes, for example, paper, card stock, envelopes, labels, transparent film, cardboard, rigid panels, and the like. In one embodiment, print media **19** is a continuous form or continuous web print media **19**. As such, print media **19** may include a continuous roll of unprinted paper.

Ink supply assembly **14**, as one embodiment of a fluid supply, supplies ink to printhead assembly **12** and includes a reservoir **15** for storing ink. As such, ink flows from reservoir **15** to printhead assembly **12**. In one embodiment, ink supply assembly **14** and printhead assembly **12** form a recirculating ink delivery system. As such, ink flows back to reservoir **15** from printhead assembly **12**. In one embodiment, printhead assembly **12** and ink supply assembly **14** are housed together in an inkjet or fluidjet cartridge or pen. In another embodiment, ink supply assembly **14** is separate from printhead assembly **12** and supplies ink to printhead assembly through an interface connection, such as a supply tube (not shown).

Mounting assembly **16** positions printhead assembly **12** relative to media transport assembly **18**, and media transport assembly **18** positions print media **19** relative to printhead assembly **12**. As such, a print zone **17** within which printhead assembly **12** deposits ink drops is defined adjacent to nozzles **13** in an area between printhead assembly **12** and print media **19**. Print media **19** is advanced through print zone **17** during printing by media transport assembly **18**.

In one embodiment, printhead assembly **12** is a scanning type printhead assembly, and mounting assembly **16** moves printhead assembly **12** relative to media transport assembly **18** and print media **19** during printing of a swath on print media **19**. In another embodiment, printhead assembly **12** is a non-scanning type printhead assembly, and mounting assembly **16** fixes printhead assembly **12** at a prescribed position relative to media transport assembly **18** during printing of a swath on print media **19** as media transport assembly **18** advances print media **19** past the prescribed position.

Electronic controller **20** communicates with printhead assembly **12**, mounting assembly **16**, and media transport assembly **18**. Electronic controller **20** receives data **21** from a host system, such as a computer, and includes memory for temporarily storing data **21**. Typically, data **21** is sent to inkjet printing system **10** along an electronic, infrared, optical or other information transfer path. Data **21** represents, for example, a document and/or file to be printed. As such, data **21** forms a print job for inkjet printing system **10** and includes one or more print job commands and/or command parameters.

In one embodiment, electronic controller **20** provides control of printhead assembly **12** including timing control for ejection of ink drops from nozzles **13**. As such, electronic controller **20** defines a pattern of ejected ink drops which form characters, symbols, and/or other graphics or images on print media **19**. Timing control and, therefore, the pattern of ejected ink drops, is determined by the print job commands and/or command parameters. In one embodiment, logic and drive circuitry forming a portion of electronic controller **20** is located on printhead assembly **12**. In another embodiment, logic and drive circuitry forming a portion of electronic controller **20** is located off printhead assembly **12**.

FIG. **2** illustrates one embodiment of a portion of printhead assembly **12**. Printhead assembly **12**, as one embodiment of a fluid ejection device, includes an array of drop ejecting elements **30**. Drop ejecting elements **30** are formed on a substrate **40** which has a fluid (or ink) feed slot **42** formed therein. As such, fluid feed slot **42** provides a supply of fluid (or ink) to drop ejecting elements **30**.

In one embodiment, each drop ejecting element **30** includes a thin-film structure **50**, a barrier layer **60**, an orifice layer **70**, and a drop generator **80**. Thin-film structure **50** has a fluid (or ink) feed opening **52** formed therein which communicates with fluid feed slot **42** of substrate **40** and barrier layer **60** has a fluid ejection chamber **62** and one or more fluid channels **64** formed therein such that fluid ejection chamber **62** communicates with fluid feed opening **52** via fluid channels **64**.

Orifice layer **70** has a front face **72** and an orifice or nozzle opening **74** formed in front face **72**. Orifice layer **70** is extended over barrier layer **60** such that nozzle opening **74** communicates with fluid ejection chamber **62**. In one embodiment, drop generator **80** includes a resistor **82**. Resistor **82** is positioned within fluid ejection chamber **62** and is electrically coupled by leads **84** to drive signal(s) and ground.

While barrier layer **60** and orifice layer **70** are illustrated as separate layers, in other embodiments, barrier layer **60** and orifice layer **70** may be formed as a single layer of material with fluid ejection chamber **62**, fluid channels **64**, and/or nozzle opening **74** formed in the single layer. In addition, in one embodiment, portions of fluid ejection chamber **62**, fluid channels **64**, and/or nozzle opening **74** may be shared between or formed in both barrier layer **60** and orifice layer **70**.

In one embodiment, during operation, fluid flows from fluid feed slot **42** to fluid ejection chamber **62** via fluid feed opening **52** and one or more fluid channels **64**. Nozzle opening **74** is operatively associated with resistor **82** such that droplets of fluid are ejected from fluid ejection chamber **62** through nozzle opening **74** (e.g., substantially normal to the plane of resistor **82**) and toward a print medium upon energization of resistor **82**.

In one embodiment, printhead assembly **12** is a fully integrated thermal inkjet printhead. As such, substrate **40** is formed, for example, of silicon, glass, or a stable polymer, and thin-film structure **50** includes one or more passivation or insulation layers formed, for example, of silicon dioxide, silicon carbide, silicon nitride, tantalum, poly-silicon glass, or other material. Thin-film structure **50** also includes a conductive layer which defines resistor **82** and leads **84**. The conductive layer is formed, for example, by aluminum, gold, tantalum, tantalum-aluminum, or other metal or metal alloy. In addition, barrier layer **60** is formed of one or more layers of material including, for example, a photoimageable epoxy resin, such as SU8, and orifice layer **70** is formed of one or more layers of material including, for example, a photopolymer, such as SU8, or a metallic material, such as nickel, copper, iron/nickel alloys, palladium, gold, or rhodium. Other materials, however, may be used for barrier layer **60** and/or orifice layer **70**.

FIG. **3** illustrates one embodiment of a portion of a fluid ejection device with the orifice layer removed. Fluid ejection device **100** includes a fluid ejection chamber **110**, a fluid restriction **120**, and a fluid channel **130**. In one embodiment, fluid ejection chamber **110** includes an end wall **112**, opposite sidewalls **114** and **116**, and end walls **118** and **119**. As such, boundaries of fluid ejection chamber **110** are defined generally by end wall **112**, opposite sidewalls **114** and **116**, and end walls **118** and **119**. In one embodiment, sidewalls **114** and **116** are contoured to follow a profile of an orifice communicated with fluid ejection chamber **110**, as described below.

In one embodiment, fluid restriction **120** communicates with and is provided in a fluid flow path between fluid channel **130** and fluid ejection chamber **110**. Parameters of fluid restriction **120** and fluid channel **130** are defined to optimize operation or performance of fluid ejection device **100**, as described below.

In one embodiment, fluid restriction **120** includes sidewalls **122** and **124**, and fluid channel **130** includes sidewalls **132** and **134**. In one embodiment, sidewalls **122** and **124** are substantially linear and oriented substantially parallel with each other. In addition, sidewalls **122** and **124** are each oriented substantially perpendicular to fluid ejection chamber **110** and, more specifically, end wall **112** of fluid ejection chamber **110**. In addition, in one embodiment, sidewalls **132** and **134** of fluid channel **130** are substantially linear and are each oriented at an angle to fluid restriction **120** and, more specifically, sidewalls **122** and **124** of fluid restriction **120**.

In one embodiment, fluid channel **130** communicates with a supply of fluid via a fluid feed slot **104** (only one edge of which is shown in the figures) formed in a substrate **102** of fluid ejection device **100**. As described above, fluid channel **130** communicates with fluid restriction **120** and, as such, supplies fluid from fluid feed slot **104** to fluid ejection chamber **110** via fluid restriction **120**.

In one embodiment, one or more islands **106** are formed on substrate **102** of fluid ejection device **100** within fluid channel **130**. Islands **106** provide a particle tolerant architecture which helps to prevent particles which may be present in the fluid from entering fluid channel **130** and, therefore, fluid restriction **120** and fluid ejection chamber **110**.

In one embodiment, a resistor **140**, as one embodiment of a drop generator, is communicated with fluid ejection chamber **110** such that droplets of fluid are ejected from fluid ejection chamber **110** by activation of resistor **140**, as described above with reference to resistor **82** and FIG. **2**. As such, the boundaries of fluid ejection chamber **110** are defined to encompass or surround resistor **140**. In one embodiment, resistor **140** includes a single resistor. It is, however, within the scope of the present invention for resistor **140** to include a split resistor or multiple resistors.

In one embodiment, as illustrated in FIG. **3**, fluid ejection chamber **110**, fluid restriction **120**, and fluid channel **130** of fluid ejection device **100** are defined in a barrier layer **150** as formed on substrate **102**. In addition, in one embodiment, as illustrated in FIG. **4**, an orifice layer **160** having an orifice **162** formed therein is provided over barrier layer **150** of fluid ejection device **100**. Accordingly, orifice **162** communicates with fluid ejection chamber **110** such that fluid ejected from fluid ejection chamber **110** is expelled through orifice **162**.

In one embodiment, a contour of fluid ejection chamber **110** follows a profile of orifice **162**. For example, sidewalls **114** and **116** of fluid ejection chamber **110** are contoured to follow the profile of orifice **162**. As such, in one embodiment, sidewalls **114** and **116** of fluid ejection chamber **110** each include an arcuate portion having a radius of curvature greater than that of orifice **162**. In one exemplary embodiment, the radius of curvature of the arcuate portions or "cheeks" of fluid ejection chamber **110** is equal to a radius of orifice **162** plus three microns.

FIG. **5** illustrates another embodiment of a portion of a fluid ejection device with the orifice layer removed. Fluid ejection device **200**, similar to fluid ejection device **100**, includes a fluid ejection chamber **210**, a fluid restriction **220**, and a fluid channel **230**. In one embodiment, fluid ejection chamber **210** includes an end wall **212**, sidewalls **214** and **216**, and end walls **218** and **219** arranged in a manner similar to that of fluid ejection chamber **110**.

In one embodiment, fluid restriction **220** communicates with and is provided in a fluid flow path between fluid ejection chamber **210** and fluid channel **230**. Similar to fluid restriction **120** and fluid channel **130** of fluid ejection device **100**, parameters of fluid restriction **220** and fluid channel **230** are defined to optimize operation or performance of fluid ejection device **200**, as described below. In one embodiment, fluid restriction **220** and fluid channel **230** include respective sidewalls **222** and **224**, and sidewalls **232** and **234** arranged in a manner similar to that of fluid ejection device **100**.

In one embodiment, fluid channel **230** communicates with a supply of fluid via a fluid feed slot **204** (only one edge of which is shown in the figures) formed in a substrate **202** of fluid ejection device **200**. In addition, similar to that described above, a resistor **240**, as one embodiment of a drop generator, is communicated with fluid ejection chamber **210** such that droplets of fluid are ejected from fluid ejection chamber **210** by activation of resistor **240**.

As illustrated in the embodiment of FIG. **5**, and similar to that described above with reference to fluid ejection device **100**, fluid ejection chamber **210**, fluid restriction **220**, and fluid channel **230** of fluid ejection device **200** are defined in a barrier layer **250** as formed on substrate **202**. In addition, as illustrated in the embodiment of FIG. **6**, an orifice layer **260** having an orifice **262** formed therein is provided over barrier layer **250** of fluid ejection device **200**. Accordingly, orifice **262** communicates with fluid ejection chamber **210** such that fluid ejected from fluid ejection chamber **210** is expelled through orifice **262**.

In one embodiment, a plurality of fluid ejection devices **100** and/or **200** are formed on a common substrate and are arranged to substantially form one or more columns of drop ejecting elements. As such, drop ejecting elements of respective fluid ejection devices **100** and/or **200** may be used for ejecting different color inks from printhead **12**. In one exemplary embodiment, fluid ejection device **100** is optimized for use with black ink and fluid ejection device **200** is optimized for use with a colored ink, as described below.

In one embodiment, as illustrated in FIGS. **3-6** and as outlined in the tables of FIGS. **7** and **8**, various parameters of fluid ejection device **100** and fluid ejection device **200** are selected to optimize or improve performance of fluid ejection device **100** and fluid ejection device **200**. In one embodiment, for example, a width W and a length L of fluid restrictions **120** and **220** are optimized. In addition, a shelf length or distance D from an edge of fluid feed slots **104** and **204** to a center of respective fluid ejection chambers **110** and **210** is optimized. Furthermore, an area of resistors **140** and **240**, and a diameter d of orifices **162** and **262** are also optimized.

In one exemplary embodiment, as illustrated in the tables of FIGS. **7** and **8**, parameters of fluid ejection device **100** and fluid ejection device **200** are optimized with a thickness of respective orifice layers **160** and **260** being generally fixed. For example, parameters of fluid restrictions **120** and **220** such as width W, length L, and a height H of fluid restrictions **120** and **220**, as described below, are optimized to optimize or improve performance of fluid ejection device **100** and fluid ejection device **200**.

In one embodiment, width W of fluid restrictions **120** and **220** is substantially constant and is measured between respective sidewalls **122** and **124** and sidewalls **222** and **224**. In addition, length L of fluid restrictions **120** and **220** is measured along respective sidewalls **122** and **124** and sidewalls **222** and **224** between sidewalls **132** and **134** and sidewalls **232** and **234** of respective fluid channels **130** and **230** and end walls **118** and **119** and **218** and **219** of respective fluid ejection chambers **110** and **210**.

In one embodiment, barrier layers **150** and **250** each have a thickness defining a height H (see FIG. **2**). As described above, barrier layers **150** and **250** may be formed of one or more layers of material. As such, the thickness of barrier layers **150** and **250** contributes to the height or depth of fluid ejection chambers **110** and **210**, fluid restrictions **120** and **220**, and fluid channels **130** and **230**. Thus, by optimizing parameters of fluid ejection devices **100** and **200**, the volume and/or rate of fluid supplied to fluid ejection chambers **110** and **210** can be optimized.

In one embodiment, the feed rate of fluid ejection chambers **110** and **210** is directly proportional to the cross-sectional area of respective fluid restrictions **120** and **220**. Accordingly, the cross-sectional area of fluid restrictions **120** and **220** is defined by the height or depth of fluid restrictions **120** and **220** and the width of fluid restrictions **120** and **220**. As such, in one embodiment, the cross-sectional area of fluid restrictions **120** and **220** is substantially rectangular in shape. The cross-sectional area of fluid restrictions **120** and **220**, however, may be other shapes.

In one embodiment, the total impedance to flow through fluid restrictions **120** and **220** to respective fluid ejection chambers **110** and **210** is optimized so as to avoid overfilling of fluid ejection chambers **110** and **210**. As such, fluid ejection devices **100** and **200** are optimized so as to maintain a substantially constant impedance to flow of fluid to respective fluid ejection chambers **110** and **210** over a desired operating range. In one exemplary embodiment, fluid ejection devices **100** and **200** are each optimized so as to maintain a substantially constant impedance to flow of fluid to respective fluid ejection chambers **110** and **210** over an operating range up to at least approximately 48 kilohertz.

In one embodiment, fluid restrictions **120** and **220** each have a fluid restriction parameter. In one embodiment, the fluid restriction parameter is defined by the following equation:

$$(2*W+2*H)*L/(H*W),$$

wherein W is the width of respective fluid restrictions **120** and **220**, H is the height of respective fluid restrictions **120** and **220**, and L is the length of respective fluid restrictions **120** and **220**. As such, the fluid restriction parameter of fluid restrictions **120** and **220** is optimized to optimize operation or performance of respective fluid ejection devices **100** and **200**.

In one embodiment, as outlined in the table of FIG. **7**, the fluid restriction parameter is optimized to be in a range of 1.5 to 5.75. As such, in one exemplary embodiment, with the thickness of orifice layers **160** and **260** selected to be 20 microns+/−1 micron and the thickness of barrier layers **150** and **250** and, therefore, height H of respective fluid restrictions **120** and **220** selected to be approximately 17 microns, width W and length L of fluid restrictions **120** and **220** are selected to optimize the fluid restriction parameter.

In another embodiment, as outlined in the table of FIG. **8**, the fluid restriction parameter is optimized to be in a range of 1.5 to 4.5. As such, in one exemplary embodiment, with the thickness of orifice layers **160** and **260** selected to be 14 microns+/−1 micron and the thickness of barrier layers **150** and **250** and, therefore, height H of respective fluid restrictions **120** and **220** selected to be approximately 14 microns, width W and length L of fluid restrictions **120** and **220** are selected to optimize the fluid restriction parameter. In another exemplary embodiment, with the thickness of orifice layers **160** and **260** selected to be 14 microns+/−1 micron and the thickness of barrier layers **150** and **250** and, therefore, height H of respective fluid restrictions **120** and **220** selected to be approximately 17 microns, width W and length L of fluid restrictions **120** and **220** are selected to optimize the fluid restriction parameter.

Accordingly, as noted with the above examples, the thickness of barrier layers **150** and **250** and, therefore, height H of respective fluid restrictions **120** and **220**, as well as width W and length L of fluid restrictions **120** and **220** are selected to optimize the fluid restriction parameter. Various combinations of height H, width W, and length L of fluid restrictions **120** and **220**, therefore, may be selected to optimize the fluid restriction parameter.

In one embodiment, in addition to optimizing parameters of fluid ejection devices **100** and **200**, as described above, properties of fluid ejected from fluid ejection devices **100** and **200** are also optimized to optimize performance of fluid ejection devices **100** and **200**. For example, properties of fluid ejected from fluid ejection devices **100** and **200** are optimized to optimize drop weight and drop velocity of droplets ejected from fluid ejection devices **100** and **200**, as well as optimize a high frequency response of fluid ejection devices **100** and **200**.

In one embodiment, for example, surface tension and/or viscosity of fluid ejected from fluid ejection devices **100** and **200** is optimized to optimize performance of fluid ejection devices **100** and **200**. In one exemplary embodiment, surface tension of the fluid ejected from fluid ejection devices **100** and **200** is in a range of approximately 21 dynes/centimeter to approximately 35 dynes/centimeter, and viscosity of the fluid ejected from fluid ejection devices **100** and **200** is in a range of approximately 1.5 centipoises to approximately 4.0 centipoises.

In one embodiment, fluid ejection devices **100** and **200** are optimized to produce droplets of substantially uniform or constant drop weight. In one exemplary embodiment, a drop weight of droplets ejected from fluid ejection devices **100** and **200** is in a range of approximately 3.5 nanograms to approximately 10.5 nanograms. In addition, in one embodiment, a frequency at which droplets of fluid are ejected from fluid ejection devices **100** and **200** is also optimized to optimize performance of fluid ejection devices **100** and **200**.

In one embodiment, as described above, fluid ejection device **100** is tuned to optimize performance with one fluid (or ink), such as a black ink, and fluid ejection device **200** is tuned to optimize performance with another fluid (or ink), such as a colored ink. Parameters of fluid ejection devices **100** and **200**, such as width W and length L of respective fluid restrictions **120** and **220**, therefore, are selected to optimize the respective performance. Parameters of fluid ejection devices **100** and **200**, however, remain within the overall system ranges. Accordingly, fluid ejection devices **100** and **200** may accommodate one or more different inks while being designed within the same system parameters.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this invention be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A fluid ejection device, comprising:

a fluid chamber;

a fluid restriction communicated with the fluid chamber;

a fluid channel communicated with the fluid restriction; and

a fluid feed slot communicated with the fluid channel,

wherein a distance from an edge of the fluid feed slot to a center of the fluid chamber is in a range of approximately 45 microns to approximately 58 microns,

wherein the fluid restriction has a fluid restriction parameter defined as (2*W+2*H)*L/(H*W), wherein W is a width of the fluid restriction, H is a height of the fluid restriction, and L is a length of the fluid restriction, and wherein the fluid restriction parameter is in a range of 1.5 to 5.75.

2. The fluid ejection device of claim **1**, wherein the width of the fluid restriction is substantially constant between the fluid channel and the fluid chamber.

3. The fluid ejection device of claim **1**, further comprising:

a resistor formed within the fluid chamber, wherein the resistor has an area in a range of approximately 200 square microns to approximately 625 square microns.

4. The fluid ejection device of claim **1**, further comprising:

an orifice communicated with the fluid chamber, wherein the orifice has a diameter in a range of approximately 12 microns to approximately 18.5 microns.

5. The fluid ejection device of claim **1**, further comprising:

an orifice communicated with the fluid chamber, wherein a contour of the fluid chamber follows a profile of the orifice.

6. The fluid ejection device of claim **5**, wherein the contour of the fluid chamber includes an arcuate portion having a radius of curvature greater than a radius of the orifice.

7. A fluid ejection device, comprising:

a substrate having a fluid feed slot formed therein;

a barrier layer formed on the substrate, wherein the barrier layer defines a fluid chamber, a fluid restriction communicated with the fluid chamber, and a fluid channel communicated with the fluid feed slot of the substrate and the fluid restriction; and

an orifice layer provided over the barrier layer and having an orifice formed therein communicated with the fluid chamber, wherein the orifice layer has a thickness of approximately 14 microns, and the barrier layer has a thickness of approximately 14 microns,

wherein the fluid restriction has a fluid restriction parameter defined as (2*W+2*H)*L/(H*W), wherein W is a width of the fluid restriction, H is a height of the fluid restriction, and L is a length of the fluid restriction, and wherein the fluid restriction parameter is in a range of 1.5 to 5.75.

8. The fluid ejection device of claim **7**, wherein the width of the fluid restriction is substantially constant between the fluid channel and the fluid chamber.

9. The fluid ejection device of claim **7**, further comprising:

a resistor formed on the substrate and communicated with the fluid chamber, wherein the resistor has an area in a range of approximately 200 square microns to approximately 625 square microns.

10. The fluid ejection device of claim **7**, wherein the orifice has a diameter in a range of approximately 12 microns to approximately 18.5 microns.

11. The fluid ejection device of claim **7**, wherein a contour of the fluid chamber follows a profile of the orifice.

12. The fluid ejection device of claim **7**, further comprising:

a supply of fluid communicated with the fluid channel, wherein the fluid has a surface tension in a range of approximately 21 dynes per centimeter to approximately 35 dynes per centimeter, and a viscosity in a range of approximately 1.5 centipoises to approximately 4.0 centipoises.

13. The fluid ejection device of claim **12**, wherein the fluid ejection device is adapted to eject drops of the fluid at a frequency up to at least approximately 48 kilohertz with each of the drops having a weight in a range of approximately 4 nanograms to approximately 9 nanograms.

14. A fluid ejection device, comprising:

a substrate having a fluid feed slot formed therein;

a barrier layer formed on the substrate, wherein the barrier layer defines a fluid chamber, a fluid restriction communicated with the fluid chamber, and a fluid channel communicated with the fluid feed slot of the substrate and the fluid restriction; and

an orifice layer provided over the barrier layer and having an orifice formed therein communicated with the fluid chamber, wherein the orifice layer has a thickness of approximately 20 microns, and the barrier layer has a thickness of approximately 17 microns,

wherein the fluid restriction has a fluid restriction parameter defined as (2*W+2*H)*L/(H*W), wherein W is a width of the fluid restriction, H is a height of the fluid restriction, and L is a length of the fluid restriction, and wherein the fluid restriction parameter is in a range of 1.5 to 5.75.

15. The fluid ejection device of claim **14**, wherein the width of the fluid restriction is substantially constant between the fluid channel and the fluid chamber.

16. The fluid ejection device of claim **14**, further comprising:

a resistor formed on the substrate and communicated with the fluid chamber, wherein the resistor has an area in a range of approximately 200 square microns to approximately 625 square microns.

17. The fluid ejection device of claim **14**, wherein the orifice has a diameter in a range of approximately 12 microns to approximately 18.5 microns.

18. The fluid ejection device of claim **14**, wherein a contour of the fluid chamber follows a profile of the orifice.

19. The fluid ejection device of claim **14**, further comprising:

a supply of fluid communicated with the fluid channel, wherein the fluid has a surface tension in a range of approximately 21 dynes per centimeter to approximately 35 dynes per centimeter, and a viscosity in a range of approximately 1.5 centipoises to approximately 4.0 centipoises.

20. The fluid ejection device of claim **19**, wherein the fluid ejection device is adapted to eject drops of the fluid at a frequency up to at least approximately 48 kilohertz with each of the drops having a weight in a range of approximately 4 nanograms to approximately 9 nanograms.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,517,056 B2
APPLICATION NO. : 11/352678
DATED : April 14, 2009
INVENTOR(S) : Elizabeth A. Fellner et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 2, line 62, before "through" insert --12--, therefor.

Signed and Sealed this

Fifteenth Day of September, 2009

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office